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Panels inspection behind the gilded finishes through Terahertz Time-Domain Imaging (THz-TDI)

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Pulsed Terahertz Time-Domain Imaging (THz-TDI) in reflection mode has been applied to the investigation of gilded tempera panel replicas, for the study of their internal structure and as an aid to understand the applied execution techniques.

The knowledge of the inner structure, stratigraphy and condition of the subsurface layers of multi-layer objects is highly relevant in conservation when stability problems such as delamination, internal cracking or defects are considered. Unlike infrared reflectography and X-ray radiography, THz-TDI provides not only 2-D images but also subsurface 3-D images. Furthermore, unlike cross-sectioned samples it provides stratigraphic images (b-scans) contactless and non-invasively. Terahertz radiation is non-ionizing due to the low photon energy (1 THz ~ 4.1 meV) and has very low power levels (approximately 1 microwatt), so that the inner structure of artifacts may be visualized without adverse effects on the artifact.

The tempera panels investigated were realized by students of "The Royal Danish Academy of Fine Arts" (Copenhagen, Denmark). One of them (Panel 1, Fig. 1a) faithfully reproduces the indications of the famous Cennino Cennini treatise, the "Book of Art", written at the beginning of the Fifteenth century. The replica has great value since many constituent layers were intentionally left exposed. A cloth piece was applied on the wooden support, and then covered by the primer layer (animal glue and plaster mixture). The ultramarine pigment was applied mixed with egg on a first drawing sketched by pencil. A golden finish, realized through the application of gold leafs on a red bole layer, frames the pictorial scene. The other panel replica (Panel 2, Fig. 2a) is also realized on a wooden support covered by the primer layer. The pictorial scene is more complex, since the gilding has been used extensively as decorative theme together with the painting material to represent textile. Engravings on the gilding are used to represent geometrical and floral motives.

We employed a portable THz imaging instrument (Picometrix T-Ray 4000) for the data acquisition.

The recorded time parametric terahertz reflection images of Panel 1 (Fig. 1b) show the grain of the wood located behind the primer layer and, interestingly, also partially under the gilding. This is due to the extremely small thickness of the gold leaves which can typically range between 0.01 - 0.125 μm (thinner than or comparable to the skin depth of gold in the THz range). The part of the canvas hidden by the primer has been localized through 2D terahertz time parametric images (Fig. 1b) and 3D Time-Of-Flight plots (Fig. 1c), revealing the extension of the wood surface covered by the canvas. The wood surface covered by the primer has been imaged, thereby demonstrating that inspection of this buried layer is possible.

Owing to the high reflectivity of gold, terahertz images of Panel 2 reveal that the majority of the paint layer has been applied on the gilding, except for some details, where the paint layer has been applied directly on the primer (Fig. 2b). Defects of buried layers have been imaged trough Time-of-Flight plots (Fig. 2c).

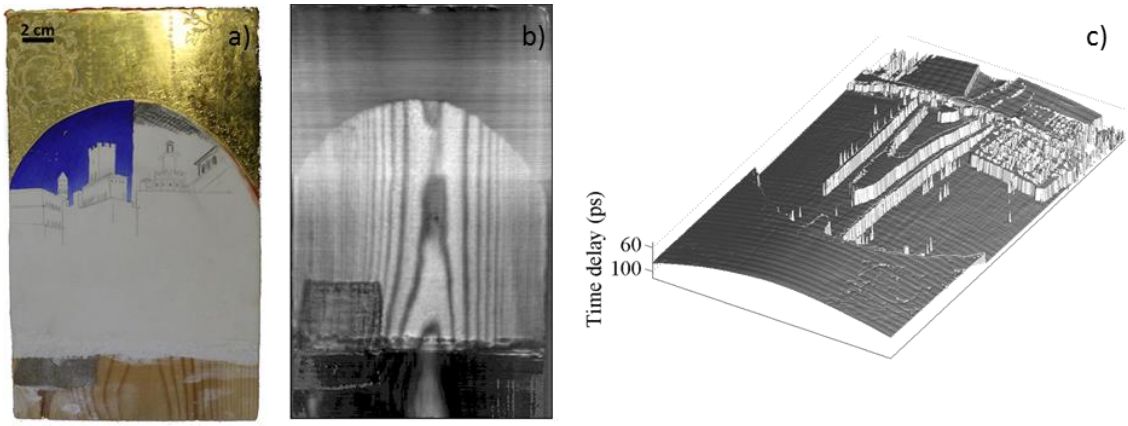

Fig. 1 a) Panel 1, visible image; b) terahertz time parametric image revealing the extension of the wood surface covered by the canvas c) Time of Flight plot, showing the wood and the canvas surfaces covered by the primer layer. Owing to the high reflectivity of gold, terahertz images of Panel 2 reveal that the major of the paint layer has been applied on the gilding, except for some details, where the paint layer has been applied directly on the primer. Defects of buried layers have been imaged trough Time-of-Flight plots.

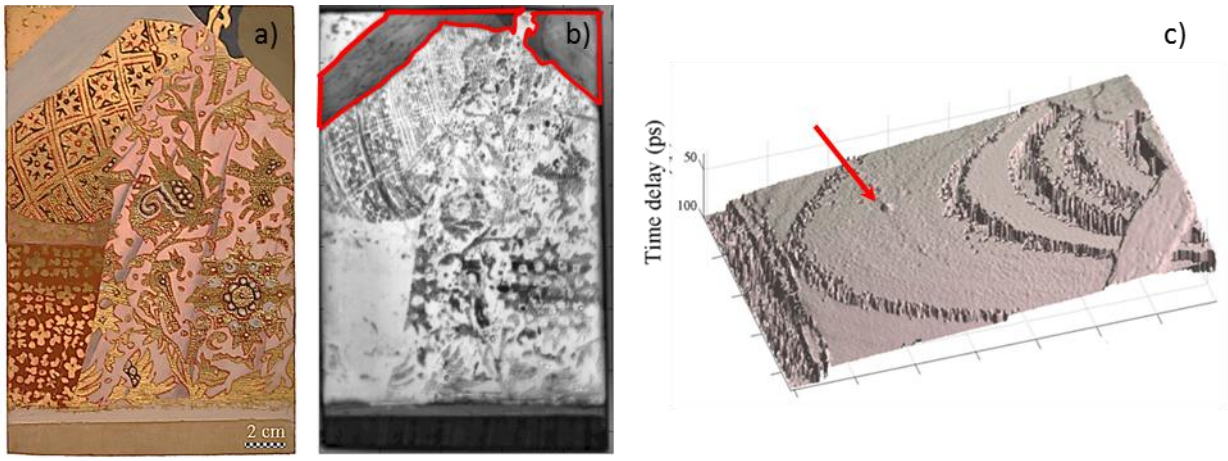

Fig. 2 a) Panel 2, visible image. b) Terahertz time domain parametric image revealing where the gold leaf is not under the paint layer (area traced in red) c) Time of Flight plot, showing the buried layer and the defect (indicated by the red arrow).